AD-A097 992 DEFENCE RESEARCH ESTABLISHMENT OTTAWA (ONTARIO) F/G 18/4
CALIBRATION OF RADIAC CALIBRATOR TYPE AN/UDM-1A.(U)
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RESEARCH AND DEVELOPMENT BRANCH

DEPARTMENT OF NATIONAL DEFENCE
CANADA

DEFENCE RESEARCH ESTABLISHMENT OTTAWA

9 TECHNICAL NOTE NO. 80-14

1 CALIBRATION OF RADIAC CALIBRATOR TYPE AN/UDM-1A

by

10 Eric [redacted]W. Jones [redacted] D.E. Benyon
Protective Sciences Division
David

12 26

11 OCT[redacted]
OTTAWA

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ABSTRACT

The Radiac Calibrator type AN/UDM-1A has recently been acquired and installed at 9 Canadian Forces Bases across Canada and in Europe. The AN/UDM-1A Calibrator is 120 Ci of ^{137}Cs and provides the required gamma radiation fields for the calibration of CF radiac equipment. This report provides a detailed description of the calibrator and method of the measurement of the gamma fields.

RÉSUMÉ

Le modèle du Calibrateur Radiac AN/UDM-1A a été récemment acquis et installé dans neuf Bases des Forces Canadiennes, réparties au Canada et en Europe. Ce Calibrateur est une source de rayon gamma au ^{137}Cs de 120 Ci qui fournit un champ de radiation adéquat pour l'étalonnage de l'équipement Radiac CF. Ce rapport décrit le Calibrateur Radiac et fournit des données sur les mesures du champ de rayons gammas.

INTRODUCTION

CALIBRATOR DESCRIPTION

The Radiac Calibrator Type AN/UDM-1A (hereinafter called the AN/UDM-1A) has been acquired by the Canadian Forces to provide them with a facility suitable for the calibration of high-range, gamma-survey, radiacmeters. A built-in attenuation system will provide for the calibration of lower-range gamma-survey radiacmeters.

The AN/UDM-1A (as supplied by its manufacturer) consists essentially of a suitably housed, nominal 120-Ci ^{137}Cs source projecting a conical radiation beam in line with and above a floor-mounted, scaled track (Figure I). A wheeled carriage runs along the track to support the radiacmeter being calibrated. A height-adjusting mechanism on the carriage table and a pointer on its base allows the detecting element of a radiacmeter to be centred in the radiation beam and to be set at some chosen distance from the radioactive source. The ^{137}Cs source is located off-centre in a small lead-filled outer container. A manually operated lever mechanism allows the source to be located in one of two positions in line with a conical opening through the outer container. In the "open" position the source is positioned adjacent to the inner opening of the conical aperture. In the "attenuated" position the source container is rotated to interpose its main body between the source and the aperture opening (figure II). It is to be noted that the source moves with respect to the fixed floor track when changing from the "open" to the "attenuated" position. For safe storage when not in use, a lever-operated, lead-filled, conical plug can be inserted into the aperture opening. It has been suggested that this plug affords a further degree of attenuation so that very low, known radiation fields can be obtained by leaving the aperture plug in place while rotating the source to its "open" position.

CALIBRATION REQUIREMENTS

For convenience of use by the Canadian Forces, the calibration of specific radiacmeters using the AN/UDM-1A facility will require the production of suitable holding jigs to properly locate each radiacmeter on the carriage table and the availability of calibration tables listing the track settings necessary to expose a radiacmeter to its "calibration" and other selected "check" radiation fields. It is envisaged that the calibration

tables will allow for source decay by changing the track settings at suitable time intervals. The information needed to prepare the tables will result from measurements taken at the DREO AN/UDM-1A installation and from a knowledge of the radiation field vs. distance relationship for each of the other installations. This stage of the calibration procedure will be a separate task and is not covered in this Technical Note.

CALIBRATION METHOD

CALIBRATION EQUIPMENT

To monitor the performance of any radiation-measuring equipment, particularly when such equipment has to be transported to and from each AN/UDM-1A installation, it is essential that it be accompanied by a reference radiation source. This requirement could most conveniently be met by using the DREO Victoreen Condenser-r-Meter.

The Victoreen calibration equipment is composed of a quartz-fibre reader and a set of unsealed ionization chambers one of which is provided with a portable radium reference check source. The system has proved to be highly reliable although it suffers from the disadvantage of sometimes requiring long exposure times. It has been observed that any performance changes which have occurred have been associated with small changes in the sensitivity of the quartz-fibre reader and not with the changes in the sensitivities of the ionization chambers. Any change of reader sensitivity can be observed and allowed for by checking the reference (25 R) ionization chamber against its reference radiation source. An apparent change in reader sensitivity can result from a change in the reader's zeroing voltage during an exposure of one of the ionization chambers. A zeroing-voltage monitor devised by one of the authors (DEB) permits compensation for any zero voltage change, virtually eliminating this source of error.

Since the 25-R, 1-R and 25-mR chambers used for the site calibrations were relatively new to DREO experience, it was necessary to establish their correction factors during the course of the site calibrations. An aneroid barometer and some thermometers were taken to each site to monitor changes in atmospheric pressure and temperature during the calibration exposures to allow correction factors to be applied to the unsealed chamber readings.

To ensure that gross errors in site measurements could not pass unnoticed an independent calibration system, the TS-5071 Calibration Set, was taken to each installation to measure the "open" source radiation field at, or close to, the nominal distance of 1 metre. This calibration system employs a set of sealed quartz-fibre pocket dosimeters and a constant, radium reference source.

CALIBRATION PROCEDURES

GENERAL

DREO's experience with high-energy gamma source installations similar to the AN/UDM-1A has shown that the inverse-square law holds provided that an effective source centre is appropriately obtained. This relationship holds over a considerable range of distances and is confirmed by a suitable transformation of the results obtained by the U.S. National Bureau of Standards in an exact calibration of a specific AN/UDM-1A facility (NRS Project 243418, November 1973).

It should be noted that secondary electrons from the source container and its attenuator(s) are present near the source and these must be excluded when making gamma measurements at short distances from the source.

The calibration procedure was therefore aimed at measuring the radiation fields over a sufficient range of distances to calculate an "effective" source location and also to establish the degree to which a simple inverse-square-law relationship is valid. Since any error in the location of an "effective" source centre is of more concern at very close distances and since the prime purpose of the AN/UDM-1A is to produce high-intensity radiation fields, more weight was given to the close-in measurements when choosing a "best-fit" for the experimental results.

A five-minute exposure of the Victoreen 25-R medium-energy chamber to its radium check source gives a reading of very close to 80% of a full-scale reading of the quartz-fibre reader. To avoid measurement uncertainties caused by any non-linearity of the quartz-fibre system all exposure times were selected to produce readings as close as possible to this same scale point. In selecting exposure times, allowance was made for the various chamber correction factor values. It was also confirmed that the quartz-fibre movement was linear within reading error over at least a small range of movement on either side of the reference reading. Reading error for a trained observer is estimated to be not more than 0.25%.

It has been noted at DREO that the response to the 25-R medium-energy chamber to ^{137}Cs (energy) radiation, when checked at a distance of 1.0 m from the source, was not changed by adding to the chamber various thicknesses of a Lucite sleeve up to about 5 mm. This was taken to mean that the wall of the chamber itself is thick enough to establish electronic equilibrium at ^{137}Cs energy at least for distances of 1.0 m or more. Since secondary electrons are known to be present close to the AN/UDM-1A source, all site

measurements with this chamber were made with a 4- to 5-mm Lucite sleeved fitted over the chamber.

The 1.0-R chamber was used for the measurement of the open-source radiation fields at distances of 2.0 m and over and the "attenuated" fields at distances of 1.0 m and over. Measurements of the attenuated fields at 0.707 m and 0.5 m were made with a sleeve fitted over the 1.0-R chamber to exclude secondary electrons from the source. This sleeve attenuated the 1.0 m field by about 1% so a correction factor of 1.01 was applied to the close-in measurements.

It might be noted that some uncertainty as to the energy dependence of any of the Victoreen chambers will not result in a radiacmeter calibration error since the individual site calibrations will be consistent relative to the DREO ^{60}Co source.

SITE CALIBRATIONS

The detector reference location was chosen to be vertically above the intersection of the lines engraved near the front of the calibration table. Since the table pointer just above the track scale is about 14 cm behind this reference location and since the scale is only approximately zeroed under the source centre, the track scale was used to determine the relative location only of any detector.

A few "trial and error" series of field measurements using a DREO exposure-rate meter allowed an approximate source location with respect to the reference table line to be determined at the first site visited (Esquimalt). More accurate field measurements using the Victoreen 25-R chamber at nominal 0.5-m, 0.707-m, 1.0-m, 1.414-m and 2.0-m source-to-detector distances gave a more precise "best fit to inverse-square law" source location. For future reference, this information was translated into a "reference distance" viz. the distance between the table reference line when set at the nominal 1.0-m point and the front of the source castle just below the beam aperture. This reference distance was used as a starting point at the other installations.

It was also noted during the first visit to Esquimalt that a large part of the radiation field emitted when the aperture plug was left in place and the source moved to its "open" position came from the annular region of the plug and castle cone interface rather than through the plug itself. The field present, at least for close-in distances, was highly non-uniform and could well depend critically upon the closeness of the plug-to-cone fit (figure II). In view of the large uncertainties associated with such a situation, it was decided that a shield should be provided to cover the annular interface region. These shields were manufactured at DREO and were fitted at each installation when "aperture-plug" measurements were made.

When the source is in the attenuated position it is physically moved from its open position and it may be expected that there will be a change in the "nominal" 1-m location. The manufacturer's drawings indicate a movement

of about 3.8 cm (1.5 in) but some early measurements indicated that the apparent movement of the "effective" source centre was significantly less than 3.8 cm and this lesser distance was used as a starting point for site calibrations of the attenuated radiation fields.

The essential stages of each site calibration were as follows although the chronological order indicated was often varied.

(i) All the equipment was allowed to stabilize to environmental conditions with electrical equipment switched on.

(ii) Victoreen chamber leakages were checked to be zero or, in the case of the 25-mR chamber which generally did show some leakage over the very long exposure times it required, to be low.

(iii) The aneroid barometer was checked against a local standard in an effort to establish an absolute measure of the atmospheric pressure. Since the Victoreen chambers are unsealed, pressure and temperature correction factors need to be applied to the observed exposure readings. It might be noted that accurate, absolute values are not essentially required since any resulting error from this source would be compensated by the "apparent" value of the correction factor found for the 25-R chamber when it is exposed to its radium standard.

(iv) The correction factor for the 25-R chamber was determined from the average dose received in a series of at least six 5-minute exposures to its radium reference source.

(v) The table reference location was set at a predetermined reference distance from the front of the source castle and the corresponding pointer track scale reading noted. Thereafter, the table could be moved to the desired nominal distances by suitable adjustment of the track setting. The table height was adjusted to centre the Victoreen chambers in the radiation beam.

(vi) Measurements of the open source radiation fields at the nominal 0.5-m, 0.707-m, 1.0-m, 1.414-m and 2.0-m locations were made using the 25-R chamber fitted with its 4- to 5-mm lucite sleeve.

(vii) At the 2.0-m distance the table height was adjusted to centre the 1.0-R chamber in the radiation beam. The mean of several exposures of the 1.0-R chamber at this nominal 2.0-m distance enabled a calibration factor for the 1.0-R chamber to be calculated with respect to the calibration factor of the 25-R chamber. The 1.0-R chamber was then used to measure the fields at the nominal 3.163-m, 4.0-m and 5.0-m distances. (At Montreal, with its longer exposure room, measurements were made at longer distances.)

(viii) The table was reset to the nominal 1.0-m distance and its height adjusted to expose the quartz-fibre dosimeter chambers side-on at the centre of the beam. The calibration factors for four of the quartz-fibre dosimeters were determined by exposing each for 50 minutes in the TS-5071 radium source. At least two exposures of each dosimeter were made to establish a mean calibration factor. The set of four dosimeters were exposed to the AN/UDM-IA field at the nominal 1.0-m distance for a time sufficient for them to receive

a nominal 8.0-R dose. Several such exposures were made to provide a fairly accurate, independent measurement of the 1.0-m radiation field.

(ix) The radiation fields with the source in its "attenuated" position were measured at the nominal 0.5-m, 0.707-m, 1.0-m and 1.414-m distances using the 1.0-R chamber. An allowance for the apparent source movement was made in the track scale settings when obtaining the nominal distances and a sleeve to exclude secondary electrons was fitted over the chamber for the 0.5-m and 0.707-m measurements.

(x) The 25-mR chamber was compared with the 1.0-R chamber at the nominal 1.414-m setting and used to measure the radiation fields out to 5.0 m.

(xi) The radiation fields for the "aperture-plug" position (aperture plug and shield left in place and the source moved into its open position) were measured using the 25-mR chamber at the nominal 1.0 m, 1.414 m and at a distance calculated to produce the required 80% of full scale dose after an overnight exposure of 16 hours. The numbers of exposure distances checked was limited to three due to the very long exposure times involved.

CALIBRATION RESULTS

The site calibration results in raw form are contained in two unnumbered DREO laboratory notebooks held by Mr. D.E. Benyon of Nuclear Effects Section, Protective Sciences Division, DREO. The results which follow in this note summarize the raw data information.

TABLE 1

25-R Victoreen Medium-Energy Chamber Calibration

Date	DREO ^{60}Co Calibration Factor	5-min DREO Radium Source Dose	Product
July 1977	0.940	19.640	18.462*
June 1978	0.953	19.430	18.516
May 1978	0.948	19.510	18.495
July 1978	0.950	19.400	18.430
July 1978	0.941	19.600	18.444
Aug 1978	0.949	19.520	18.524
Aug 1978	0.947	19.470	18.438
Feb 1979	0.953	19.410	18.498
Mar 1979	0.953	19.445	18.531
		MEAN	18.484

* In general, the three decimal places have been retained to avoid later round-off error.

The correction factor for the 25-R chamber at any time during the course of a site calibration is therefore given by:

$$CF = 18.484 \div \text{Mean 5-min radium dose}$$

and the result can be expected to be accurate (with respect to DREO ^{60}Co standards) to within about 0.25%.

TABLE 2

Ratios of Chamber Correction Factors

Location	Date	Correction-Factor Ratio	
		1R:25R	25mR:1R
Montreal	Jan 1978	1.223	0.86
Lahr	Mar 1978	1.214	--
DREO	May 1978	1.223	--
Toronto	Jun 1978	1.228	--
Valcartier	Sep 1978	1.227	0.874
Edmonton	Nov 1978	1.215	0.866
Esquimalt	Feb 1979	1.221	0.866
Halifax	Apr 1979	1.225	0.871
Winnipeg	Sep 1979	1.223	0.865
Montreal	Jan 1979	--	0.861
Toronto	Jun 1979	1.220	0.855
Lahr	Oct 1979	1.223	0.866
DREO	Jan 1980	--	0.856
		MEAN 1.222	MEAN 0.864

While the observed chamber factor ratios may have varied from the mean values due to real causes peculiar to any site, the final site-normalized results have used the mean ratios shown here to establish chamber calibration-factor values relative to the 25-R chamber calibration-factor values found at each site from a radium standard reference measurement.

TABLE 3

Open-Source Radiation Fields

Location	Date	Exposure Rate (R/h) at Nominal 1.0m		Reference Distance (cm)
		Victoreen Measurement	Quartz Fibre Dosimeters	
Esquimalt	Oct 1977	41.36	41.31	87.2
Montreal	Jan 1978	39.33	39.71	86.8
Lahr	Mar 1978	41.62	41.22	87.2
DREO	May 1978	40.08	40.17	86.9
Toronto	Jun 1978	41.30	41.16	87.4
Valcartier	Sep 1978	39.49	39.32	87.5
Edmonton	Nov 1978	41.68	41.28	86.6
Esquimalt	Feb 1979	39.96	---	87.2
Halifax	Apr 1979	39.94	40.15	86.7
Winnipeg	Sep 1979	38.48	38.48	87.0
Montreal	Jan 1979	38.10	---	86.8
Lahr	Oct 1979	39.71	39.54	87.2
Toronto	Jun 1979	40.0	---	87.4

It is considered that open-source fields shown above are consistent with respect to the DREO ^{60}Co standards to within about 1%.

TABLE 4

Attenuated-Source Radiation Fields

Location	Date	Exposure-Rate (R/h) at Nominal 1.0 m	Reference Distance[1] (cm)	Attenuation Factor[2]
Montreal	Jan 1978	0.551	85.5	1.40×10^{-2}
DREO	May 1978	0.532	85.5	1.33×10^{-2}
Toronto	Jun 1978	0.560	84.6	1.36×10^{-2}
Valcartier	Sep 1978	0.581	85.7	1.47×10^{-2}
Edmonton	Nov 1978	0.596	84.5	1.43×10^{-2}
Esquimalt	Feb 1979	0.572	84.0	1.43×10^{-2}
Halifax	Apr 1979	0.524	85.0	1.31×10^{-2}
Winnipeg	Sep 1979	0.545	85.2	1.42×10^{-2}
Lahr	Oct 1979	0.543	85.2	1.37×10^{-2}

Note 1: It should be noted that the nominal 1.0 m point moves in toward the source in the attenuated position and also that the apparent movement is, in most cases, significantly less than the actual physical movement of the source shown in manufacturer's drawings viz. 3.8 cm.

Note 2: The factor shown is an apparent attenuation multiplying factor which relates the attenuated radiation field at its nominal 1.0 meter to the open source field at its different nominal 1.0 meter.

It is considered that attenuated fields shown above are consistent with respect to the DREO ^{60}Co standards to within 2%.

TABLE 5

Aperture-Plug Radiation Fields

Location	Date	Exposure-Rate (mR/h) at Nominal 1.0m[1]	Attenuation Factor[2]
Montreal	Jan 1979	8.71	2.29×10^{-4}
DREO	May 1978	10.65	2.66×10^{-4}
Toronto	Jun 1979	8.69	2.17×10^{-4}
Valcartier	Sep 1978	7.82	1.98×10^{-4}
Edmonton	Nov 1978	10.16	2.44×10^{-4}
Esquimalt	Feb 1979	8.60	2.10×10^{-4}
Halifax	Apr 1979	8.99	2.25×10^{-4}
Winnipeg	Sep 1979	8.06	2.09×10^{-4}
Lahr	Oct 1979	8.48	2.14×10^{-4}

Note 1: The nominal 1.0 m point has been taken to be the same as that found for the open-source radiation fields.

Note 2: The factor shown is an apparent attenuation multiplying factor which relates the aperture-plug field to the corresponding open-source field.

SOURCE DECAY

A few sites were visited on two separate occasions since a requirement for measuring very low exposure rates was not initially known and the necessary measuring chambers had to be acquired and used on a second visit. There was a sufficient time interval between the visits to allow an estimate of the source decay to be made. The results are shown below.

Location	Decay Period From	To	Observed Decay Factor[1]	^{137}Cs Decay Factor
Esquimalt	Oct 1977	Feb 1979	0.967	0.970
Montreal	Jan 1978	Jan 1979	0.969	0.977
Toronto	Jun 1978	Jun 1979	0.970	0.977
Lahr	Mar 1978	Oct 1979	0.956	0.966
DREO	May 1978	Jan 1980	0.954	0.964

Note 1: Decay factor is based upon attenuated radiation field measurements but since the ^{137}Cs and ^{134}Cs gamma energies are close, the effect of the attenuation should not significantly change the observed decay factor.

Although the discrepancies between the observed decay factors and the predicted ^{137}Cs decay factor could result from a cumulative 0.5% error in each of the field measurements used, the consistently lower value of the observed decay suggests that the cause lies in a small percentage presence of a short-lived (2 years) ^{134}Cs impurity.

An analysis of the Lahr measurements suggests that the total activity of the March 1978 source contained about 2.6% ^{134}Cs. The DREO results suggests the same ^{134}Cs impurity content in the DREO source in May 1978. The results for Montreal and Toronto are consistent with a similar content; whereas the Esquimalt results suggest a lesser content. In the absence of repeated measurements for the other sources it may be reasonable from a practical point of view to assume that all sources had about a 2.5% ^{134}Cs impurity at the time of their initial calibration and that their decay will be about 1% lower than a predicted ^{137}Cs decay for each 2-yr period thereafter up to 1981. If all the sources are similar in respect to their ^{134}Cs content their radiation fields will be lower than those predicted by a ^{137}Cs decay by about 2% by 1982 and thereafter the ^{134}Cs may be ignored.

The validity of an inverse-square law behaviour of site radiation fields with respect to an "effective" source centre may be inferred from the normalized results shown in Tables I, II, III of the Appendix. The normalizing factor is shown as the ratio of the measured exposure-rate at

various source-to-detector distances to the exposure-rate which would have been predicted from an exact inverse-square-law treatment of the nominal 1.0-m field.

Table I suggests that a typical deviation of about 0.5% from inverse-square law might be expected for the open-source fields over the distance range 0.5m to 4.0m distance: at Montreal with its longer exposure room an inverse-square-law behaviour continues out to at least 6.0 m.

Table II suggests a similar agreement with inverse-square over the distance range 0.5 m to 5.0 m, again with the exception of Montreal where different conditions prevail, for the attenuated fields. The absence of excessive scatter from the rear wall for the attenuated fields is probably due to the much smaller area of the wall exposed to the more closely collimated radiation beam.

Table III indicates that the very low radiation fields obtained by the use of the aperture plug are much more uncertain and the few measurements which could be taken suggest a possible uncertainty of ±5% over a distance range 1.0 to 3.0m.

SUMMARIZING CONCLUSIONS

It is considered that the radiation fields obtainable at the various AN/UDM-1A installations can be determined from the results contained in this note to within an accuracy of 2% with respect to the DREO ^{60}Co reference standards over the distance ranges 0.5 m to 4.0 m for the open-source condition and 0.5 m to 5.0 m for the attenuated-source condition. When the sources use their aperture plugs to obtain very low exposure-rates an uncertainty of 5% is possible over the limited 1.0-m to 3.0-m distance range which could be investigated.

Since the exposure-rates measured included a small contribution from scatter from the table supporting the measuring equipment, a substantial change of table and the presence of a monitoring TV camera in proximity to the detectors might change the exposure-rates slightly in an absolute sense. Such a possible change should be investigated at the DREO installation so that an allowance can be made, if necessary, at other sites if some of the measurements are repeated at some later date to confirm source decay, i.e. to correct for a ^{134}Cs impurity content.

The proposed method of obtaining the calibration table for the various CF radiacmeters involves the following steps:

(i) Calibrate a typical instrument(s) to read correctly when exposed to its ^{60}Co (DREO) calibration field.

(ii) Transfer the instrument to the DREO AN/UDM-1A and determine the location which reproduces the calibration reading. Calculate the value of the AN/UDM-1A field for that location.

(iii) Using the nominal 1.0-m fields for the other locations calculate the distances required to produce the field obtained in step (ii). This distance will be shown in the appropriate calibration table.

(iv) Check-calibrations at other selected scale points will follow a similar procedures and will allow two limiting distances representing an acceptable accuracy to be added to the calibration tables for each calibration check point.

(v) To allow for source decay the above distances will be changed accordingly at suitable time intervals.

APPENDIX

The best-fitting of the measured radiation fields at various distances from an effective source centre to an inverse-square law behaviour used the expression:

$$D = x/\left(\sqrt{\frac{F_D}{F_{D+x}}} - 1\right)$$

where F_D and F_{D+x} were the measured fields at source-to-detector distances D and D+x respectively.

Since x was measurable to a much higher degree of accuracy than either of the associated radiation fields, the possible error in a calculation of D is determined mainly by the measurement uncertainty of the radiation fields.

The field measurements taken over the nominal source-to-detector distance range 0.5 m to 2.00 m were used, for the open and attenuated source positions, to determine a value for D for the x value 0.207 m, 0.5 m, 0.914 m and 1.5 m. If a consistent value of D different from 0.5 m was calculated it was assumed that a correction to the initial 0.5 m setting was required. In such cases, inverse-square-law corrections were applied to radiation fields measured at the initial settings to assign values proper to the new nominal source-to-detector distance.

The value of radiation field assigned to the nominal 1.0 m distance was the mean of the products of the radiation field (corrected) and the square of the source-to-detector distance for each of the selected distances over the 0.5-m to 2.00-m range.

In Tables I and II field intensities shown were calculated, based upon fields measured at points very close to the nominal distances.

TABLE I

Open Source, Inverse-Square-Law Behaviour

Nominal Distance (m)	Ratio of Measured Field to Inverse-Square-Law Field								
	Montreal	DREO	Toronto	Valcartier	Edmonton	Esquimalt	Halifax	Winnipeg	Lahr
0.5	1.000	1.000	1.001	1.002	0.998	1.002	1.000	1.000	1.003
0.707	1.001	1.001	1.001	1.003	1.004	1.008	1.000	1.002	0.998
1.00	0.999	0.9995	1.000	0.998	1.000	1.000	1.005	1.000	0.998
1.414	0.999	-	-	-	-	-	-	-	-
2.00	1.004	0.9995	1.004	1.006	1.000	0.989	1.003	0.995	1.001
3.162	1.001	1.006	-	0.991	1.004	-	0.994	0.990	0.994
4.00	0.995	1.009	1.012	1.001	0.994	1.001	1.000	1.00	1.004
5.00	1.002	Not obtainable	1.050	1.040	1.040	1.040	1.040	1.034	1.040
6.00	1.002	-	-	-	-	-	-	-	-
7.00	1.02	-	-	-	-	-	-	-	-

TABLE II

Attenuated-Source, Inverse-Square-Law Behaviour

Nominal Distance (m)	Ratio of Measured Field to Inverse-Square-Law Field								
	Montreal	DREO	Toronto	Valcartier	Edmonton	Esquimalt	Halifax	Winnipeg	Lahr
0.5	1.001		1.00	0.994	0.985	1.001	0.967	0.986	0.986
0.707	0.999	0.992	1.009	0.994	0.988	1.00	0.997	0.997	0.999
1.00	1.001	1.006	1.009	1.00	1.003	1.00	1.001	1.002	1.00
1.414	1.008	0.99	0.99	1.002	1.003	1.00	1.002	1.003	1.00
2.00	0.998	1.002	1.00	0.999	1.008	1.00	1.005	1.008	1.003
3.162	-	1.005	-	-	0.999	0.994	0.997	0.996	0.996
4.00	0.993	1.006	0.988	0.997	0.995	1.008	0.998	0.991	1.003
5.00	-	Not obtainable	-	1.005	1.019	-	1.018	-	1.014
5.65	0.987	-	-	-	-	-	-	-	-
8.00	1.005	-	-	-	-	-	-	-	-

TABLE III

Aperture-Plug, Inverse-Square-Law Behaviour

Nominal Distance (m)	Ratio of Measured Field to Inverse-Square-Law Field								
	Montreal	DREO	Toronto	Valcartier	Edmonton	Esquimalt	Halifax	Winnipeg	Lahr
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.414	0.998	1.01	1.007	1.001	1.016	1.00	1.00	1.003	0.993
d	1.028	-	0.95	1.004	1.05	1.01	1.05	1.045	1.01

d = Predicted distance to give 1.25 mR/h.

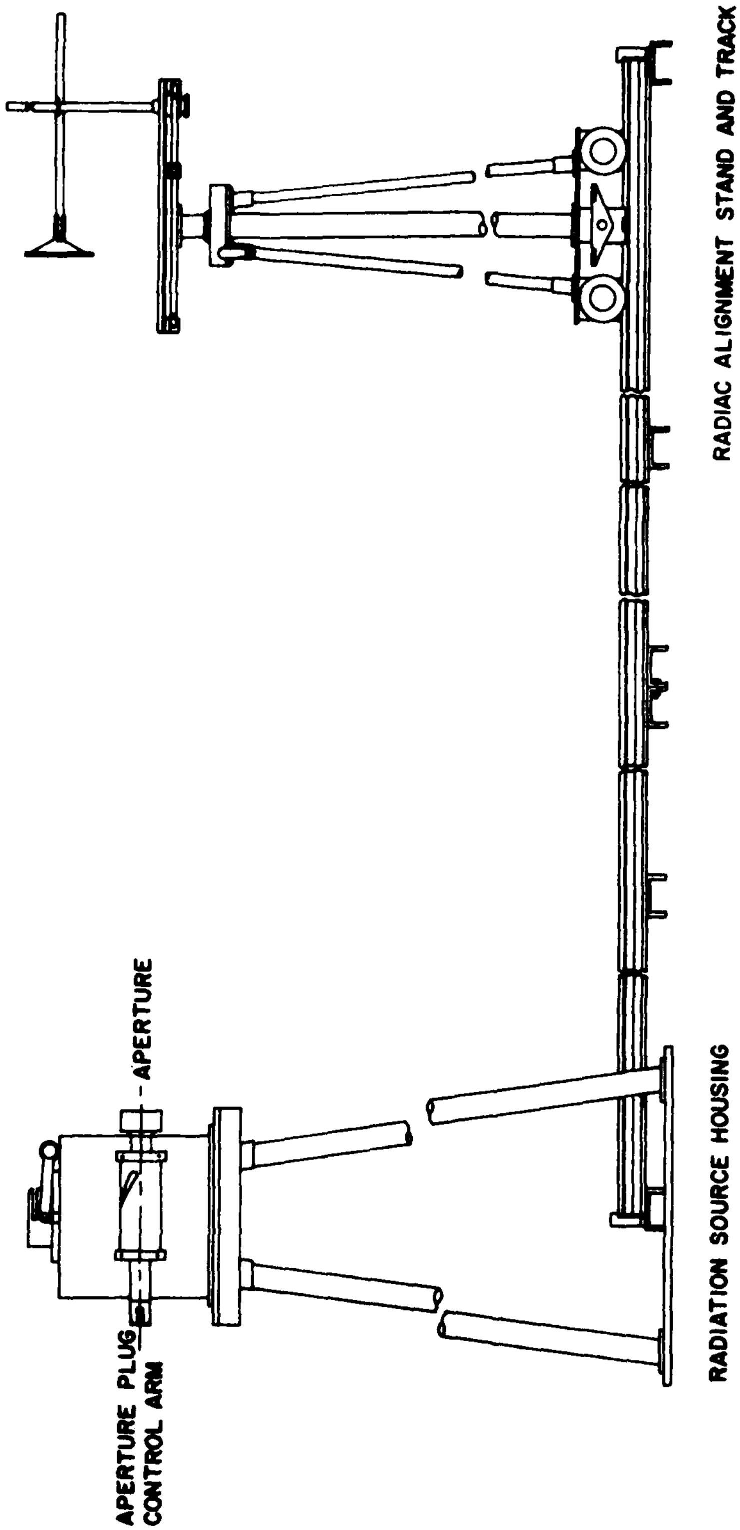

Fig. I: Radiac Calibrator Set, AN/UDM-1A.

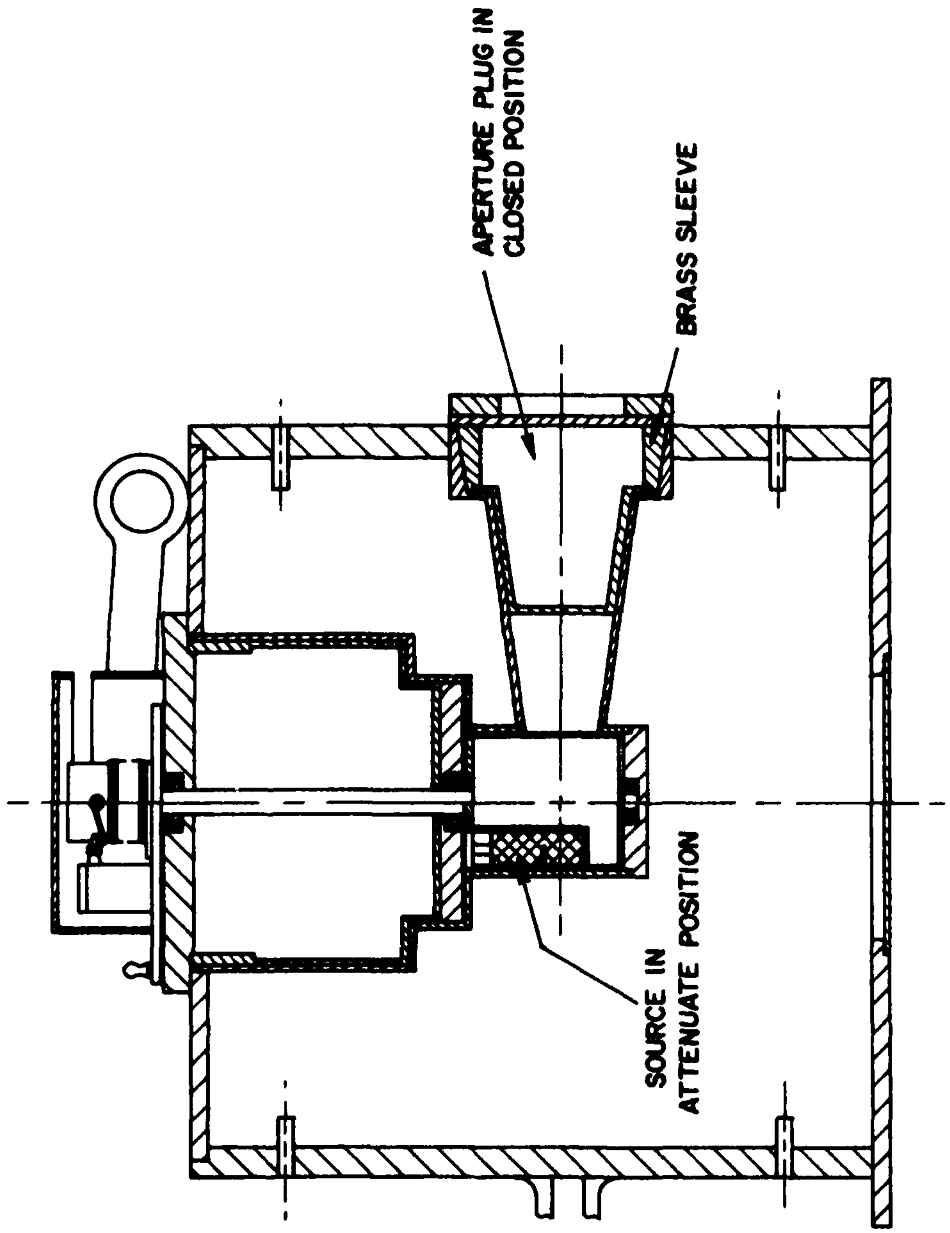

Fig. II: AN/UDM-1A Lead Castle.

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1 ORIGINATING ACTIVITY Defence Research Establishment Ottawa Department of National Defence Ottawa, Ontario, Canada K1A 0Z4	2a. DOCUMENT SECURITY CLASSIFICATION UNCLASSIFIED 2b GROUP N/A

3 DOCUMENT TITLE

CALIBRATION OF RADIAC CALIBRATOR TYPE AN/UDM-1A

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)

TECHNICAL NOTE

5 AUTHOR(S) (Last name, first name, middle initial)

JONES, Eric W. and BENYON, David E.

6 DOCUMENT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
OCTOBER 1980	20	

8a. PROJECT OR GRANT NO	9a ORIGINATOR'S DOCUMENT NUMBER(S) DREO TECHNICAL NOTE NO. 80-14
8b CONTRACT NO	9b. OTHER DOCUMENT NO.(S) (Any other numbers that may be assigned this document)

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The Radiac Calibrator type AN/UDM-1A has recently been acquired and installed at 9 Canadian Forces Bases across Canada and in Europe. The AN/UDM-1A Calibrator is 120 Ci of ^{137}Cs and provides the required gamma radiation fields for the calibration of CF radiac equipment. This report provides a detailed description of the calibrator and method of the measurement of the gamma fields.

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RADIAC CALIBRATOR AN/UDM-1A

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